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Pyriform Sinus Localization-Assisted Blind Intubation: Comparison with Laryngoscopic Intubation

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Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Background: Conventional endotracheal intubation requires laryngoscopy for a direct view of the glottis. However, laryngoscopy is associated with many potential complications. The aim of the present study was to compare the efficacy and safety of pyriform sinus localization-assisted blind orotracheal intubation with those of conventional laryngoscopic orotracheal intubation.

Material/Methods: A randomized, patient-blind, prospective study of 300 patients who underwent various operations was performed. One hundred patients were assigned to the laryngoscopic intubation group (laryngoscopy group), and 200 patients were assigned to the blind intubation group (blind group).

Results: The total intubation success rate in the blind group was similar to that in the laryngoscopy group (100% *vs.* 99%, respectively; p=0.33). Oxygen saturation by pulse oximetry in both groups was maintained at >98%. The intubation time was significantly shorter in the blind group than in the laryngoscopy group (9.7±3.4 s *vs.* 23.0±5.8 s, respectively; p<0.001). Postoperative complication rates were significantly lower in the blind group than in the laryngoscopy group. Recovery time from these symptoms was significantly shorter in the blind group than in the laryngoscopy group (p=0.004).

Conclusions: Pyriform sinus localization-assisted blind orotracheal intubation was shown to be more effective than conventional laryngoscopic orotracheal intubation in terms of success rate, intubation time, and postoperative complication rate. Moreover, it is less affected by common risk factors; thus, this method may be more beneficial in patients with difficult airways.

MeSH Keywords: Blindness • Intubation, Intratracheal • Laryngoscopy • Pyriform Sinus

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Background

Endotracheal intubation (ET) is a critical airway management technique used during anesthetic practice and emergency and critical care. Conventional ET requires laryngoscopy to clearly visualize the glottis. However, laryngoscopy is associated with many potential complications, including significant hemodynamic changes, tooth loss, oropharyngeal injury, cricoarytenoid joint dislocation, infection, and brain damage [1,2]. The performance of laryngoscopy may be restricted in some patients. Difficult (incidence, 1–18%) or failed intubation (incidence, 0.05–0.35%) may also occur because of poor laryngoscopic exposure of the posterior glottis [3–6]. Although the use of visualization technology in recent years has significantly reduced complications and difficulties associated with laryngoscopy and ET [7–10], the use of such technology has been greatly limited by high costs, low availability of proficient operators, and interference by oropharyngeal secretions. Moreover, laryngoscopy may not always be available in a timely manner in urgent situations. All of these disadvantages have greatly restricted the use of this technology [4].

Blind tracheal intubation is an alternative to laryngoscopy and is recommended to minimize invasive intubation during management of difficult airways [11–14]. In 1975, Magill developed this technique while observing an overlap of the pharyngeal and laryngeal axes. The technique was subsequently termed blind nasotracheal intubation [15]. Similar to other methods, this strategy has weaknesses. One of the most common complications of this method is nasopharyngeal bleeding. It is also easily affected by anesthesia and the patient's state of consciousness. During deep anesthesia, inhibition of respiration influences the accuracy of catheter localization; however, when conscious, patients are usually unable to tolerate blind nasotracheal intubation. Because of the angle between the thyromental line and laryngeal axis, this method is usually contraindicated in clinical practice.

Due to the aforementioned difficulties encountered during ET, a novel blind orotracheal intubation method (Zhong's blind orotracheal intubation) was created with the assistance of pyriform sinus localization. Orotracheal intubation can be easily performed because of the wide intraoral operative area. Anatomically, the epiglottis is located between the upper edge of the laryngopharynx and lower edge of the cricoid cartilage. On either side of the laryngeal orifice there is a recess termed the pyriform sinus. The pyriform sinus is a subsite of the hypopharynx and has a fixed anatomical position in relation to the throat and rima glottidis. This distinction is important for localization of the throat and rima glottidis (Figure 1).

The aim of the present study was to compare the efficacy and safety of pyriform sinus localization-assisted blind orotracheal intubation with those of conventional laryngoscopic orotracheal intubation. A randomized, patient-blind, prospective study of 300 patients was performed. The study revealed that blind orotracheal intubation with the assistance of pyriform sinus localization is equally or slightly more effective than conventional laryngoscopic orotracheal intubation.

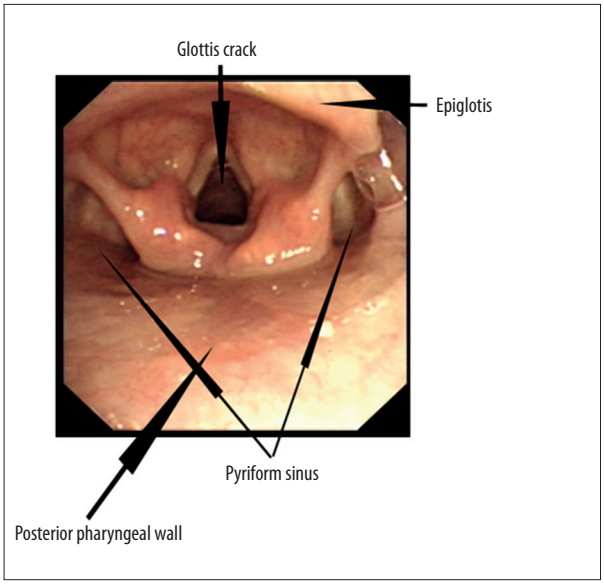

Figure 1. Anatomical position of the pyriform sinus.

Material and Methods

Patient selection

After approval by our institution's research ethics committee, informed consent was obtained from all patients. The inclusion criteria were: 1) American Society of Anesthesiologists (ASA) physical status of I or II in accordance with the definitions of the ASA Physical Status (ASA PS) class levels [16], 2) age ≥18 years, 3) no serious cardiovascular or pulmonary disease, 4) requirement for general anesthesia and ET, and 5) no coagulation dysfunction. The exclusion criteria were: 1) history of oral, ear, nose, or throat operations; 2) upper respiratory disease (e.g., tumors, polyps, severe inflammation or trauma, abscesses, or foreign objects); 3) symptoms of sore throat or hoarseness; 4) a mouth opening of <1.5 cm; 5) inability to tolerate mask ventilation; and 6) anticipated requirement for >5 h of anesthesia. The modified Mallampati scoring system utilizes the following criteria as previously described [17]: Class I: visible soft palate, uvula, fauces, and pillars; Class II: visible soft palate, uvula, and fauces; Class III: visible soft palate and base of uvula; and Class IV: visible hard palate only.

A total of 300 patients who underwent various operations from March 2012 to September 2012 met the inclusion criteria. According to the operation sequence, the patients were randomly divided into the laryngoscope group and blind group in a

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Table 1. Demographic and clinical characteristics of patients.

Characteristics	Laryngoscopy (N=100)	Blind (N=200)	P value
Sex			
Male	46 (46.0%)	85 (42.5%)	0.63
Female	54 (54.0%)	115 (57.5%)	
Age in years	50±14	48±13	0.22
Height in cm	165±6	164±6	0.12
Weight in kg	57±10	57±10	0.74
Thyromental distance in mm	75±8	74±8	0.26
Mouth opening in mm	35±3	35±3	0.27
Body mass index in kg/m^2	21.0±3.5	21.0±2.6	0.78
Mallampati score			
Class I–II	90 (90.0%)	184 (92.0%)	0.62
Class III–IV	10 (10.0%)	16 (8.0%)	

Laryngoscopy, laryngoscopy-assisted intranasal tracheal intubation; Blind, pyriform sinus localization-assisted blind intraoral tracheal intubation. Data are presented as *n* (%) or mean ± standard deviation.

1-*vs.*-2 style in which 1 patient was assigned to the conventional direct laryngoscope ET group (n=100; Model H33060 Shanghai Medical Devices Co., Ltd., Shanghai, China) and 2 patients were assigned to the pyriform sinus-assisted blind ET group (n=200).

Preoperative evaluation and anesthesia

All patients were required to fast for at least 8 h before the operation, and no premedication was given. Upon arrival in the operating room, preoperative clinical data were recorded (Table 1). Standard monitoring was instituted, including non-invasive blood pressure measurement, pulse oximetry, electrocardiography, capnography, and body temperature measurement. After adequate preoxygenation, the patients were induced with 0.1 mg/kg of midazolam, 5.0 μg/kg of fentanyl, 1.0 mg/kg of propofol, and 0.1 mg/kg of vecuronium. After 3 min, ET was performed by experienced anesthesiologists. Patients were administered continuous infusion of remifentanil and propofol during the operation. Sevoflurane was administered via inhalation to maintain anesthesia. After the operation, patients were transferred to another room for recovery. The indication for extubation was a Steward awakening score of ≥4 points postoperatively. The Steward awakening scoring system is used to evaluate postoperative recovery in patients [18]. Postoperative follow-up was performed.

Intubation procedures

Plastic endotracheal tubes with inside diameter (ID) of 7.5 mm (male patients) and 7.0 mm (female patients) were used. Patients in the laryngoscopy group were intubated with conventional direct laryngoscopic orotracheal intubation, as previously described [19]. Patients in the blind group were intubated with pyriform sinus localization-assisted blind orotracheal intubation. The key points of this method are: 1) Shape of endotracheal tube: The proximal end of an endotracheal tube with an ordinary core was bent to an angle of 90–135° in a "J"-shape. The length of the tube at the proximal end was equal to the patient's thyromental distance. The arc of the tube was nearly equal to the angle between the thyromental line and the laryngeal axis (Figure 2). 2) Position: The operator stood at the head of the patient. The patient was placed in the supine position without a pillow and with the head slightly extended, or the mandibular angle of the patient was pushed upward to keep the mouth open. 3) Intubation: The "J"-shaped tracheal tube was inserted into the mouth from the midline, close to the posterior region of the tongue. When the proximal end of the tube reached the posterior pharyngeal wall, it was swung to one side for placement at a 10–15° angle and continuously advanced until it encountered resistance, which indicated that the tube had reached the homolateral pyriform

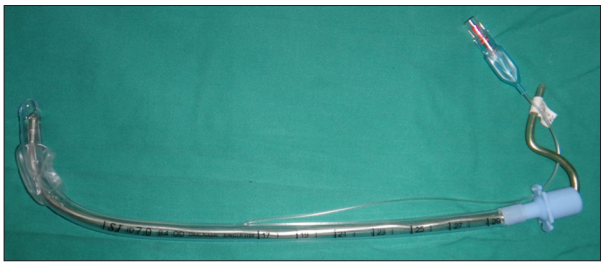

Figure 2. "J"-shaped endotracheal tube used in pyriform sinus localization-assisted blind orotracheal intubation.

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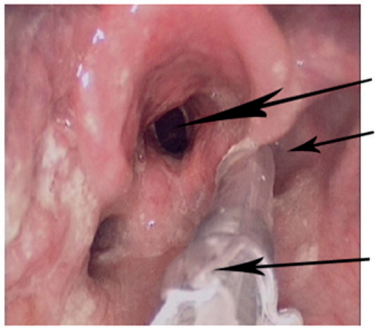

Figure 3. Endoscopic image of the endotracheal tube inserted on one side of the pyriform sinus.

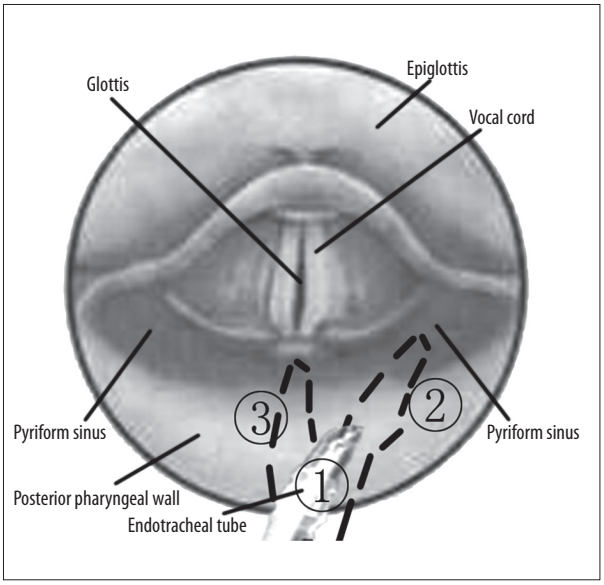

Figure 4. Diagram of pyriform sinus localization-assisted blind orotracheal intubation. Notes: 1) The "J"-shaped endotracheal tube was inserted into the mouth from the midline close to the posterior aspect of the tongue. When the proximal end of the tube reached the posterior pharyngeal wall, it was swung to one side for 10–15° angle placement. 2) The tube was continuously advanced until it encountered resistance, which indicated arrival at the homolateral pyriform sinus. 3) The tube was withdrawn for 5–8 mm, after which the proximal end of the tube was swung back to the midline and continuously advanced while the core was pulled out. A sense of emptiness indicated that the tube had successfully entered the trachea.

sinus (Figure 3). The tube was then withdrawn 5–8 mm, and the proximal end of the tube was swung back to midline and continuously advanced as the core was pulled out of the tube. A sense of emptiness indicated that the tube had successfully entered the trachea (Figure 4). 4) Fixation of the tube: After the endotracheal tube was connected to the anesthesia machine and correct position had been ensured by auscultation and confirmation of the end-tidal carbon dioxide partial pressure, it was fixed using the conventional method as previously described [17].

The following 2 key points should be kept in mind when implementing this technique: 1) Shape of the endotracheal tube: The angle between the oral and laryngeal axes changes with head movement. Additionally, the thyromental line is usually parallel with the oral axis. We usually determine the radius of the endotracheal tube according to the angle between the thyromental line and laryngeal axis. This angle is usually 90–135° and "J"-shaped, and it increases with extension of the head. 2) Location of pyriform sinus: When the proximal end of the endotracheal tube reaches the posterior pharyngeal wall, the tube should be swung to one side for 10–15° angle placement and continuously advanced. In this way, the epiglottis, which lies at the midline, can be avoided. If resistance is felt, the tube has most likely reached the homolateral pyriform sinus. At this point, the tube should be slightly withdrawn and swung to the midline, after which the tube can be easily inserted into the trachea. 3) A localized outpouching of the neck can be seen when the proximal end of the endotracheal tube touches the lateral wall of the pyriform sinus. This outpouching occurs at the posterolateral aspect of the thyroid cartilage wing and can assist with correct localization of the tube. However, in obese patients or those with neck scars or giant cervical masses, such an outpouching is usually unable to be seen. In these situations, the pyriform sinus is located by touch.

Postoperative evaluation

At the end of the operation, any residual neuromuscular blockade was reversed and the patient was extubated. The number of failed intubations, total number of attempts, intubation time, and adverse events during the entire procedure were recorded. The intubation time for a single attempt in each group was defined as the time that had elapsed between insertion of the laryngoscope or endotracheal tube into the oral cavity and complete withdrawal of the core of the endotracheal tube. The SpO_2, mean arterial pressure (MAP), and heart rate (HR) were monitored, and the presence of any oropharyngeal mucosal bleeding caused by intubation, sore throat, hoarseness, throat dryness and discomfort, and upper respiratory trauma were recorded.

Statistical analysis

All data were processed using SPSS 13.0 software (SPSS Inc., Chicago, IL, USA). For continuous variables, the data are presented as mean ± standard deviation. The independent 2-sample *t*-test was used to test differences between groups. The χ^2 test was used for categorical variables, and data are presented as number (percentage). A p value of <0.05 was considered statistically significant.

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Table 2. Intubation outcomes in each group.

Group	Completed			Failed	Intubation time in seconds
	First attempt	Second and third attempts	Mallampati score III–IV		
Laryngoscopy (N=100)	85 (85.0)	14 (14.0)	9/10 (90)	1 (1)^	23.0±5.8
Blind (N=200)	157 (78.5)	43 (21.5)*	16/16 (100)	0 (0)	9.7±3.4#

^ Failed laryngoscopic intubation, but successful blind intubation. * p=0.12, # p<0.001 compared with the laryngoscopic intubation group. Laryngoscopy, laryngoscopy-assisted intranasal tracheal intubation; Blind, pyriform sinus localization-assisted blind intraoral tracheal intubation. Data are presented as n (%) or mean ± standard deviation.

Table 3. Respiratory and hemodynamic changes during the procedures.

Parameter	Group	Preinduction	Preintubation	Intubation	Postintubation (3 min)
SpO_2 as%	Laryngoscopy	98.8±0.7	99.2±0.6	99.0±0.6	99.0±0.6
	Blind	98.9±0.6	99.5±0.6	99.1±0.7	99.3±0.6
MAP in mmHg*^	Laryngoscopy	84.0±10.1	76.1±7.5	90.0±6.9	82.2±8.5
	Blind	84.8±8.0	75.4±7.2	86.2±8.3	80.2±8.3
HR in beats/min#^	Laryngoscopy	71.9±8.6	73.7±10.4	91.5±8.1	75.7±8.1
	Blind	72.9±8.1	75.6±7.9	85.5±10.3	73.5±8.4

SpO_2, pulse oxygen saturation; MAP, mean arterial pressure; HR, heart rate; Laryngoscopy, laryngoscopy-assisted intranasal tracheal intubation; Blind, pyriform sinus localization-assisted blind intraoral tracheal intubation. * No statistically significant differences in MAP between the blind and laryngoscopy groups (F=1.96, p=0.16). ^ No statistically significant differences in comparisons among the four time points (p<0.001). # No statistically significant differences in HR between the blind and laryngoscopy groups (F=1.55, p=0.21). Data are expressed as mean±standard deviation.

Results

Preoperative demographic and clinical characteristics

In total, 300 patients were enrolled in this trial. These patients underwent gastrointestinal, gynecological, orthopedic, and other surgical procedures. One hundred patients were assigned to the laryngoscopy group and 200 patients were assigned to the blind group. Demographic and clinical characteristics of patients included sex, age, height, weight, preoperative evaluation results, ASA status, and modified Mallampati score. This information is summarized in Table 1; there were no significant differences in any of these parameters between both groups (p>0.05).

Intubation outcomes

The overall intubation success rate was 100% in the blind group and 99% in the laryngoscopy group (p=0.33). The first-time success rate was 78.5% and 85.0% (p=0.18), and the second- and third-time success rate was 21.5% and 14.0% (p=0.12) in the blind and laryngoscopy groups, respectively. No statistically significant differences in the success rates were seen between the 2 groups. In patients with Mallampati scores of III to IV, the success rate was 100% and 90% in the blind and laryngoscopy groups, respectively, with little difference between groups (p=0.39); however, 1 failed intubation in the laryngoscopy group was subsequently successfully performed using the blind intubation method. Intubation time was significantly shorter in the blind group than in the laryngoscopy group (9.7±3.4 *vs.* 23.0±5.8 s, respectively; p<0.001) (Table 2).

Respiratory and hemodynamic monitoring

The patients' respiratory and hemodynamic changes were evaluated by monitoring SpO_2, MAP, and HR. SpO_2 in both groups was maintained at >98%; MAP and HR increased upon completion of intubation, but quickly returned to normal levels. There were no significant differences between groups (MAP, p=0.16; HR, p=0.21) (Table 3).

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Table 4. Postintubation complications in the two groups.

Complication	Group	Extubation (0 h)	Extubation (12 h)	Extubation (24 h)
Bleeding	Laryngoscopy	6 (6)	2 (2)	0 (0)
	Blind	2 (1)*	0 (0)	0 (0)
Sore throat	Laryngoscopy	23 (23)	8 (8)	2 (2)
	Blind	3 (1.5)#	2 (1)^	1 (0.5)
Hoarseness	Laryngoscopy	16 (16)	8 (8)	1 (1)
	Blind	35 (17.5)	14 (7)	2 (1)
Discomfort	Laryngoscopy	21 (21)	6 (6)	2 (2)
	Blind	36 (18)	10 (5)	2 (1)

Bleeding, oropharyngeal bleeding; Discomfort, oropharyngeal discomfort; Laryngoscopy, laryngoscopy-assisted intranasal tracheal intubation; Blind, pyriform sinus localization-assisted blind intraoral tracheal intubation. * Compared with the laryngoscopy group immediately after extubation (χ^2=4.64, p=0.03); # Compared with the laryngoscopy group immediately after extubation (χ^2=38.94, p<0.001). ^ Compared with the laryngoscopy group 12 h after extubation (χ^2=8.08, p=0.004). Data are presented as n (%). Laryngoscopy, N=100. Blind, N=200.

Complications

Incidence of oral and throat bleeding was significantly lower in the blind group than in the laryngoscopy group (1% *vs.* 6%, respectively; p=0.03). Sore throat was a postoperative complaint in 1.5% of patients in the blind group and 23.0% in the laryngoscopy group (p<0.001). Time required for recovery from these complications was significantly shorter in the blind group than in the laryngoscopy group (p=0.004). At 12 h after endotracheal extubation, incidences of bleeding and sore throat were 0% and 1% in the blind group and 1% and 8% in the laryngoscopy group, respectively. At 24 h after extubation, incidences of bleeding and sore throat were 0.0% and 0.5% in the blind group and 0% and 2% in the laryngoscopy group, respectively. Incidences of hoarseness and throat discomfort were similar in both groups at all time points (Table 4).

Discussion

Results of the present study indicate that pyriform sinus localization-assisted blind ET has a success rate similar to that of conventional direct laryngoscopic ET. However, intubation time using this method was significantly shorter in the present study. The mean intubation time was 9.7 s for blind intubation and 23.0 s for laryngoscopic intubation. Thus, the blind intubation method clearly saves time, which is particularly important for patients in emergency situations.

This study included patients with Mallampati scores of III to IV. Such patients usually have expected or anticipated airway difficulties. However, we found no statistically significant difference in intubation success rate between the 2 methods. This result was most likely due to the fact that only a small number of patients with difficult airways were enrolled in this study. Sixteen patients with Mallampati scores of III underwent blind intubation, and all of them were successfully intubated. One patient underwent failed intubation using the conventional method, but was finally successfully intubated using the blind intubation method. Based on the results of the current study, we suggest that the blind intubation method may be more beneficial than the conventional method in management of patients with difficult airways, most likely because conventional laryngoscopic intubation is easily affected by many patient-related factors [13]. These risk factors include degree of mouth opening, neck range of motion, amplitude of jaw protrusion, Mallampati score, thyromental distance, obesity, and presence of oropharyngeal secretions [20–23]. However, the relative anatomical position of the pyriform sinus and throat are very stable, and this relatively fixed position is not strongly affected by the above-mentioned factors, causing potential difficulty in laryngoscopic visualization. Thus, blind intubation is easier to perform than laryngoscopic intubation, even in patients with difficult airways. The most critical step is to place the proximal end of the "J"-shaped tracheal tube on one side of the pyriform sinus; accurate pyriform sinus localization is the key to successful and rapid intubation with this method. Thus, pyriform sinus localization-assisted blind intubation is more efficient and time-saving than conventional laryngoscopic intubation, especially in patients with difficult airways.

Both blind and conventional intubation had similar effect on SpO_2 levels. During intubation, SpO_2 levels were maintained at ≥98% in both groups, suggesting that both methods are able

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to ensure normal oxygenation during intubation. Upon completion of intubation, the MAP and HR in both groups were higher than their preintubation baseline levels, but these values quickly returned to baseline levels 3 min after intubation. This suggests that although both methods are associated with changes in hemodynamic levels during intubation, these changes are rapidly recovered.

Our study also revealed that complications associated with the blind method are significantly less severe than those associated with the conventional method. Blind intubation allows for the avoidance of complications usually seen with laryngoscopic intubation, such as oral bleeding, injury to surrounding tissue, and tooth loss [2,24]. Complaints of sore throat were more common in patients who underwent laryngoscopic intubation than in those who underwent blind intubation in the present study, and the recovery time from these symptoms was longer in the laryngoscopy group.

Although we found no statistically significant complications in patients who underwent blind intubation, we are unable to conclude that there are no complications related to this procedure. Comprehensive clinical trials are required for precise determination of drawbacks and weaknesses of this method. In addition, we do not recommend application of this method in patients with upper respiratory tract disease, including tumors, cysts, severe infection or trauma, foreign objects, or severely limited degree of mouth opening.

A new airway device, the Supraglottic Airway Laryngopharyngeal Tube (S.A.L.T.), has been developed to assist with blind orotracheal intubation [25]. Anand et al. [25] evaluated the adjunctive values of the S.A.L.T. in 30 adult patients who underwent blind orotracheal intubation. They reported that only 40% of the patients were successfully intubated and thus suggested that the S.A.L.T has limited value as an adjunctive device in assisting blind orotracheal intubation [25].

Conclusions

Pyriform sinus localization-assisted blind orotracheal intubation has shown to be more effective than conventional laryngoscopic ET with regard to success rate, intubation time, and postoperative complications. Moreover, it is less affected by common risk factors of laryngoscopic intubation. Therefore, this method may be more beneficial in patients with difficult airways.

Acknowledgements

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Description of study and clinical relevance

This study was performed to find a safe and effective alternative for endotracheal intubation in management of patients with difficult airways.

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